REQUEST FOR INFORMATION

MARS SCIENCE LABORATORY CORING TOOL

The California Institute of Technology's Jet Propulsion Laboratory (JPL) is requesting information on the development of a coring tool to autonomously collect in-situ rock samples. NASA's Mars Science Laboratory (MSL) mission plans to place a scientific rover on Mars using a soft-landing approach similar to that used by the Viking missions. The spacecraft is planned for launch in the 2009 opportunity with the arrival at Mars sometime in 2010. The rover's surface mission includes performing detailed analysis of Martian regolith and rocks was well as collecting surface samples and processing the samples for distribution to rover-mounted analytical instruments. For more information about the MSL mission, see the following web site:

http://mars.jpl.nasa.gov/missions/future/msl.html

The MSL coring tool is expected to be mounted to the end of a 1.75 meter long robotic arm and collect 8-12 mm diameter rock core samples at depths up to 10 cm below the rock surface. The operational scenario for the MSL coring tool will follow the model used during the Mars Exploration Rover (MER) mission for rock abrasion activities. In the MER mission, the robotic arm places and preloads the abrasion tool against the rock surface. Once placed, the abrasion tool autonomously abrades the surface of the rock without any further interaction or intervention by the robotic arm. As such, the MSL coring tool should include all degrees-of-freedom and internal mechanisms required to perform the coring function without involving any robotic arm degrees-of-freedom. It is expected that the maximum preload that the robotic arm will provide to the interface between the coring bit and the rock surface will be 120N.

The lifetime performance of the coring tool is expected to be a significant design driver. Currently mission requirements state that the MSL rover will be designed to last for a full Martian year (approximately 700 days) and collect approximately 75 core samples during this time period. The core samples will be extracted from a variety of rock types including hard, dense basalt rocks similar to those found at the Spirit rover's Gusev Crater site and softer sedimentary rocks similar to those found at the Opportunity rover's Meridiani Planum site. The overall life requirement for the coring tool will consist of a combination of an accumulated coring depth in a hard dense rock and an accumulated coring depth in a weakly cemented rock.

For the purposes of this RFI, the vendor should assume that the accumulated coring depth in a hard dense rock is 125 cm and the accumulated coring depth in a weakly cemented rock is 400 cm. If a single coring bit is not capable of lasting for the total required accumulated coring depth, then the coring tool may be required to perform an autonomous bit change-out function in order to provide the coring tool with a fresh cutting bit. The coring tool vendor should specify in their RFI response whether or not

the bit change-out function is required and, if required, the number of bits required to meet the total accumulated coring depth and the mass associated with each coring bit.

It is also important to note that the brushless gearmotors to be used to actuate the coring tool are expected to be Government Furnished Equipment (GFE) to the subcontractor. Any additional mechanisms and output gear stages are to be designed and developed by the coring tool subcontractor. The coring tool vendor is also expected to design, fabricate and integrate any internal cabling (flex print or round wire) and deliver the integrated unit to JPL for integration with the rover and spacecraft. Once integrated with the flight spacecraft, the avionics and software required to drive the coring tool will be controlled via a central processor and motor control avionics. Therefore, the coring tool subcontractor is only required to develop Electrical Ground Support Equipment (EGSE) in order to drive the coring tool during integration and unit-level test activities including the flight qualification program.

This document is a Request For Information (RFI) from your organization regarding autonomous coring tools for in-situ rock sample acquisition. Any information provided may be used to support the process of concept development for the MSL mission. Included with this RFI is a set of reference requirements for the coring tool (see APPENDIX A -- REFERENCE REQUIREMENTS). Consider these only as a reference point for defining the coring tool. While we do not want to preclude any candidate designs from this request, we did want to provide a frame of reference for your candidate.

In your response, please include as much as you can about your design or design concept and the expected capabilities. Use the following as a guide for the types of information that may be included:

1. General Description:
    a. Physically describe the coring tool or design concept providing diagrams and/or photographs, if available.
    b. Provide mass estimates in kg for the coring tool assembly including coring bit mass if bit change-out is required.
    c. Describe the form factors and total volume estimates for the coring tool assembly.
    d. Describe the mechanical interfaces for the coring tool.
    e. Describe any internal sensors beyond motor control feedback sensors required for the successful operation of the coring tool (e.g., force sensors).
2. Flight or Technology Heritage/Qualification:
    a. Describe any heritage for your coring tool (e.g., space missions or other applications that have used, are now using or planning to use your robotic system)
    b. Describe whether your company has experiences in qualifying mechanisms and/or sensors for space flight and if so, describe the qualification program including environments used (e.g., against a MIL spec. or other)

c. Describe your coring design with respect to meeting the reference environmental requirements including stating which of these may be more difficult to satisfy.
d. Describe any test data that validates meeting the coring bit life requirement including the methodology for determining the number of bits required to meet the total accumulated coring depth.

3. Functional Test Program
    a. Describe the test program used or planned to use for the coring tool to verify and validate your design.
4. Costs:
    a. Please provide Rough Order of Magnitude (ROM) costs to deliver one engineering model coring tool in June 2007 and one flight coring tool for integration with the flight system in March 2008 assuming a contract start date of February 2006.

Since we would like to review all responses quickly after the deadline, please limit your responses to 10 pages or less. Also, we would prefer responses that can stand on their own without further explanation. However, if we have specific questions, please provide your contact information so we can get in touch with you.

Response requested by: August 12, 2005

Please send your response to:

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Project Acquisition Manager
Mail Stop 291-114
Jet Propulsion Laboratory
4800 Oak Grove Dr.
Pasadena, CA 91109
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When responding to this RFI, we ask that you indicate your interest in receiving an RFP for one or more of these technology items.

It is emphasized that the requested information is for preliminary planning purposes only and does not constitute a commitment, implied or otherwise, that JPL will solicit you for such a procurement in the future. Neither JPL nor the Government will be responsible for any costs incurred by you in furnishing this information.

Prospective contractors are advised that any information provided shall be deemed to be furnished with unlimited rights to JPL, with JPL assuming no liability for disclosure, use or reproduction of such data.

We look forward to your response.

Sincerely,

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APPENDIX A -- REFERENCE REQUIREMENTS

Part I – Environmental Requirements

Reference Requirement	Value	Notes
Operational Flight Temperature Range	-120 C to +50 C	Expect that the GFE gearmotors will be operational within this temperature range.
Non-operational Temperature Range	-135 C to +110 C	
Operational Atmospheric Composition Environment	Operate within Earth & Mars atmospheric compositions	For Mars, 95.5% CO_2 2.7% N_2 1.6% Ar 0.2% Trace
Pressure Ranges: Earth Ground Operations Thermal Vacuum Test Interplanetary Cruise Mars Atmospheric	760 torr <10e-5 torr 10e-14 torr 2 to 12 torr	Pressure decay rate = -33 torr/sec; Repressurization rate = +1 torr/sec
Random Vibration	0.89 g_{rms} Flight level	1.26 g_{rms} Qual. level
Pyroshock (1 g = 9.81 m/sec^2)	20 g +10.0 dB/octave 2,000 g	100 Hz 100 – 1,600 Hz 1,600 – 10,000 Hz
EMC/EMI	TBD	Note any known compatibility or susceptibility issues
Radiation, Total Ionizing Dose (TID)	1.7e+3 rad (Si) 3.4e+3	RDF = 1 RDF = 2
Radiation, Displacement Damage Dose (DDD)	2.2e+10 4.4e+10	RDF = 1 RDF = 2

Part II – Performance Requirements

Reference Requirement	Value	Notes
Minimum Core Length	2 cm	
Maximum Core Length	10 cm	
Core Diameter	8-12 mm	
Maximum Applied Coring Bit Preload	120N	Maximum preload at the interface between the coring bit and the rock as applied by the robotic arm
Maximum Applied Coring Tool Preload	240N	Maximum preload at the interface between the coring tool support structure and the rock as applied by the robotic arm
Rate of Penetration	>5 cm/hour	
Orientation Performance	0-90 degrees elevation, ±45 degrees azimuth	Relative to the rover reference frame with 0 degrees elevation pointing straight down and 90 degrees elevation pointing in a horizontal direction
Maximum Slope	20 deg	Coring tool shall meet all performance requirements on slopes up to 20 degrees
Lifetime	1 Mars Year	
Maximum Core Samples	75	Assume the coring tool qualification program must show 30% margin on top of the coring tool lifetime requirement